

## **CISE Update**

Farnam Jahanian
CISE Directorate
National Science Foundation

CISE Advisory Committee Meeting November 1, 2011



#### Welcome



Dr. Cindy Dion-Schwarz Deputy Assistant Director



Gera Jochum Communication Specialist



# **Snapshot of FY 2011 Activities**

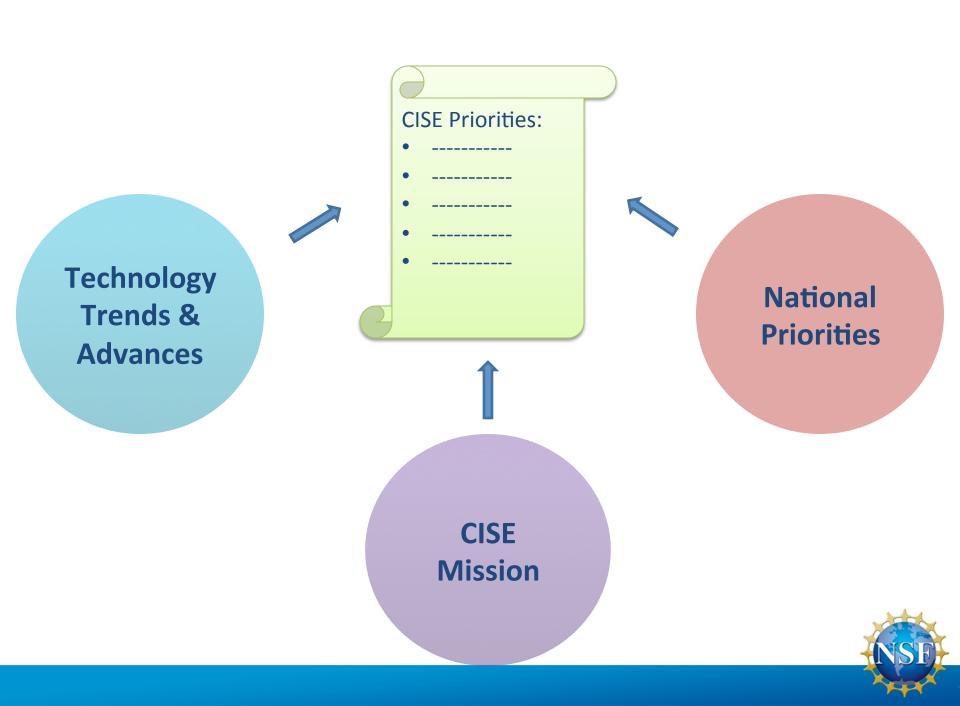
	CISE	
Research Budget (\$M)	\$635M	
Number of Proposals	5,998	
Number of Awards	1,378	
Success Rate	23%	
Average Award Size	\$164K	
Number of Panels Held	247	
Number of People Supported	14,488	



# **Supported by CISE-FY2011**

	CISE
Senior Researchers	6,812
Other Professionals	605
Postdoctoral Associates	371
Graduate Students	4,882
Undergraduate Students	1,818
Total Number of People	14,488





#### **CISE Mission**

#### Exploring the frontiers of computing

CISE Mission

- Promote progress of computer and information science and engineering research and education.
- Promote understanding of the principles and uses of advanced computer, communications and information systems in service to society.
- Contribute to universal, transparent, and affordable participation in an information-based society.

These frontiers have interfaces with all the sciences, engineering, education, and humanities and a strong emphasis on innovation for society.



Technology
Trends &
Advances

# Trends and Advances Shaping Computing and Communication

- Exponential increase in volume and complexity of data (Big Data)
- Universal connectivity and access at broadband speeds
- Melding of the cyber world with the physical world
- Explosive growth of mobile devices and distributed low-power sensors
- Emergence of multi-core, virtualization, and cloud computing
- Transformation and convergence of communications, media, entertainment, and public discourse
- Emergence of social computing, crowd sourcing, and distribution collaboration
- Increasing reliance on computation- and data-enabled techniques in scientific discoveries and engineering innovations
- All goes mainstream from machine learning, robotics, and speech recognition to augmenting human capabilities

#### **National Priorities**

- Cyber Security
- Health & Well-being
- Environment and Sustainability
- Advanced Manufacturing and Robotics
- Broadband Access, Wireless Infrastructure and Applications
- Education and Workforce Development
- Maintain IT Leadership in a Rapidly Changing Global Environment

**National Priorities** 





# Program Highlights



### **National Robotics Initiative (NRI)**

To develop the next generation of robotic companions that work seamlessly with humans as co-workers, co-protectors, co-drivers, co-explorers, and co-inhabitants to enhance personal safety, health, and productivity

- A nationally coordinated robotics technology R&D program across multiple government agencies
  - Multi-agency commitment: NSF, NASA, NIH, USDA
  - NSF: CISE, ENG, SBE, EHR
  - Up to \$50M for FY2012
- Serves multiple key national priorities: increased personal productivity in manufacturing, healthcare and security
- Strong coupling with industry and startups, through SBIRs
- Emphasizes common platforms & standard interfaces
- Will sponsor national competitions, outreach, & education



Credit: Bristol Robotics Lab



Credit: 2011 Honda Motor Co., Ltd.



# NRI Launched at the Advanced Manufacturing Partnership in June 2011





#### **NRI Research Thrusts**

Fundamental research in robotics science & engineering

- Machine perception & cognition
- Controls & planning
- Learning & adaptability
- Natural language understanding and sensing
- Robust human-robot interaction

Understanding the long term social, behavioral, and economic implications across all areas of human activity

- Models of uptake, diffusion, and use among different demographics
- Incentives, disparities and ethical implications; workforce participation
- Models of human-robot collaboration

Use of robotics to facilitate and motivate STEM learning across the K-16 continuum

- Learning across all disciplines
- Engaging learners
- Evolving robotics-centric pedagogy and outreach

# NSF Cybersecurity Activities Over Time

Trusted Computing FY 02-03

Cyber Trust FY 04-08

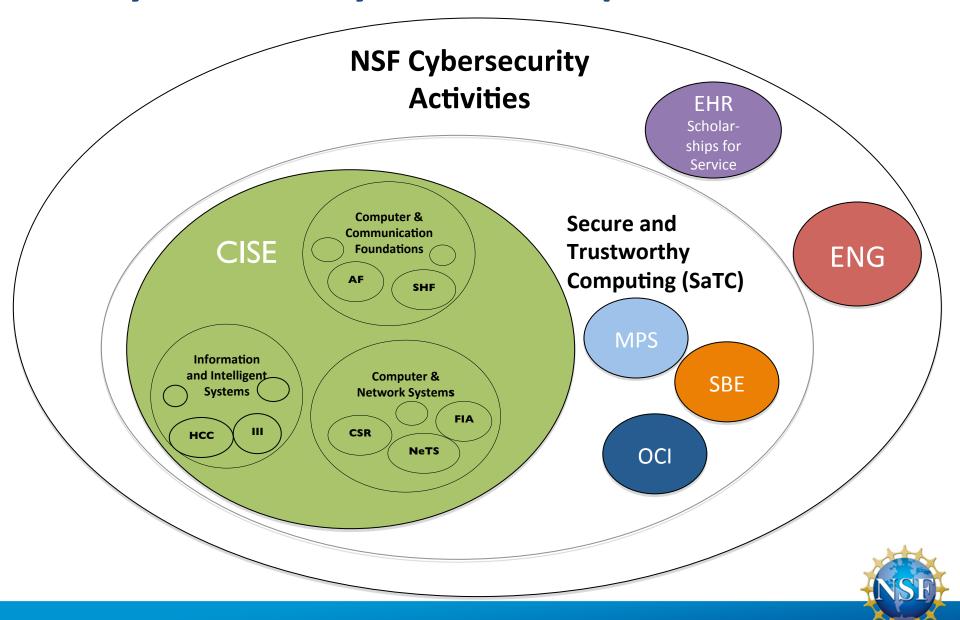
Trustworthy Computing FY 09-11

Secure and Trustworthy Cyberspace

FY 12-++



#### **NSF Cybersecurity Activities Span Directorates**



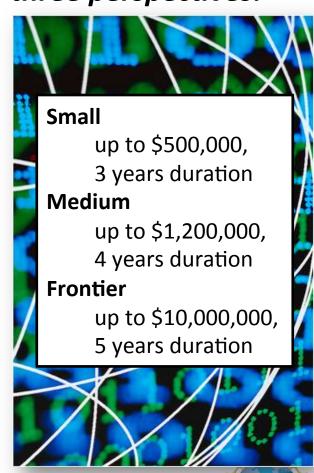




# Secure and Trustworthy Cyberspace Program (SaTC)

To address cybersecurity from one or more of three perspectives:

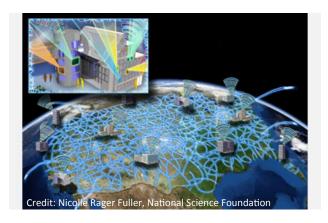
- Trustworthy Computing Systems
- Social, Behavioral and Economics
- Transition to Practice
- Cross-Directorate Program: CISE, SBE, OCI, MPS
  - Anticipated \$50M for FY 2012
- We encourage both single perspective and multi-perspective proposals
- A successful multi-perspective proposal will most likely require a strong multi-disciplinary team.



#### **Evolution of Cyber Threats**

#### Future security challenges will follow Internet adoption patterns:





- Botnets will continue to dominate how attacks are launched; attribution and forensics is increasingly difficult.
- Distributed attacks increasing in size and sophistication, targeting specific applications.
- Proliferation of attacks spurred by financial gains and now political motives.
- Proliferation of wireless devices and social media platforms open new avenues for hackers.
- Protecting cloud infrastructure key to long-term adoption.
- The trend toward increasingly cyber-enabled systems expands the scope of attacks to physical infrastructure manufacturing, energy production, healthcare and transportation.

#### SaTC Research Perspectives

# Trustworthy Computing Systems

- Perspective aims to provide scientific basis for designing, building and operating cyber-infrastructure with improved resilience and resistance
- Support for both theoretical and experimental approaches
- Investigation of tradeoff among trustworthy properties

## Social, Behavioral & Economic

- Perspective includes research at individual, group, organizational, market and societal levels, identifying risks and exploring solution feasibility
- Understanding attack or defense behaviors to develop more effective strategies and solutions
- Cyber economic incentives including metrics and models

## Transition to Practice

- Perspective addresses the challenge of moving from research to practice
- Focus on later stages of R&D activities including evaluation and experimental deployment
- Software required to be released under open software license

#### SaTC Programmatic Goals

#### Frontier Projects

- Earlier CISE programs had funded four center-scale awards with the goal of promoting synergy among academic, industrial and other partners:
  - ACCURATE, CCIED, TCIP, SAFE
- In subsequent years, we created a large category to fund smaller in-depth/multidisciplinary efforts.
- Now that the original center-scale efforts are ending/transitioning, we wish to fund new efforts

## **Cyberlearning: Transforming Education**

# To improve learning by integrating advances in technology with advances in what is known about how people learn:

- better understand how people learn with technology and how technology can be used productively to help people learn, through individual use and/or through collaborations mediated by technology;
- better use technology for collecting, analyzing, sharing, and managing data to shed light on learning, promoting learning, and designing learning environments; and
- design new technologies for these purposes, and advance understanding of how to use those technologies and integrate them into learning environments so that their potential is fulfilled.
- Cross-Directorate Program: CISE, EHR. SBE, OCI



## **Cyberlearning FY11 Awards**

- First round of awards announced at a White House event
- \$15 million to more than 30 institutions
- Innovative research projects include:
  - "GeoGames" that help students analyze data across geographical areas to solve real-world challenges;
  - Robots that use non-verbal cues to teach vocabulary to children;
  - Systems that create augmented reality for learners with hearing disabilities to support their learning; and
  - Online tutors that assess a student's real-time comprehension and tailor learning strategies to improve achievement.



**Digital Promise Announcement** 



## **Smart Health & Wellbeing**

To address fundamental technical and scientific issues that would support much needed transformation of healthcare from reactive and hospital-centered to preventive, proactive, evidence-based, person-centered and focused on wellbeing rather than disease

- Cross-Directorate Program: CISE, ENG, SBE
- eHealth, mHealth, EHR datamining, distributed care, sensor technology, participating and empowered patient, etc.
- Must relate to a key health problem and must make a fundamental contribution to ENG, CISE, or SBE domains



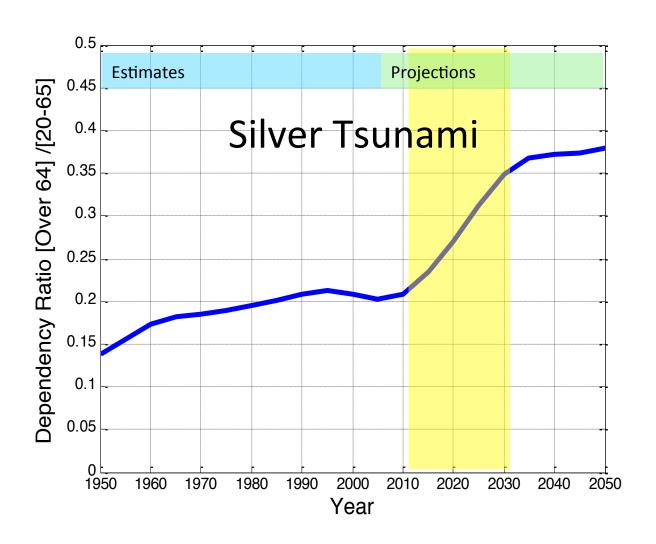
#### **The Healthcare Crisis**

#### Some troubling statistics

- The cost of healthcare in the U.S. is the highest in the world (>\$8,000 per capita, 16% GDP)
- The U.S. ranked 37<sup>th</sup> in the 2000 WHO study of healthcare system performance (8 underlying measures)
- 50% Americans have 1 or more chronic diseases; age of onset is getting younger
- 98,000 deaths per year due to medical errors
- 3 lifestyle behaviors (poor diet, lack of exercise, smoking) cause estimated 1/3rd of U.S. deaths
- Current individual medical records have an error rate of 20%
- Medicare and Medicaid costs to be at a staggering 25% of the U.S. economy by 2050



#### **Dependency Ratio: Retired/Working**





# Information and communication technologies are poised to transform healthcare ...

preventing the onset of diseases, improving diagnoses and treatments, enhancing the quality of health care delivery, and empowering us to participate in our own health and well-being



#### **Paradigm Shifts: Next Medicine**

EPISODIC, REACTIVE FOCUS ON DISEASE



PROACTIVE and PREVENTIVE FOCUS ON WELLBEING QUALITY OF LIFE

**HOSPITAL-CENTRIC** 



PATIENT-CENTRIC, HOME-BASED

TRAINING & EXPERIENCE BASED



EVIDENCE – BASED LEARNING HEALTH SYSTEM

FRAGMENTED, LOCAL DATA



INTEROPERABLE, EHR AVAILBLE ANYWHERE, ANYTIME

NAÏVE, PASSIVE, PATIENTS



EMPOWERED, ENAGAGED, INFORMED, PARTICIPATING

#### **Smart Health Research Thrusts**

Digital Health Information Infrastructure

Informatics and Infrastructure

- Continuous collection, integration, fusion and exchange of EHR, biomedical and clinical research data in a distributed but federated system
- A foundation for evidence-based, patient-centric practice & research

Data to Knowledge to Decision

Reasoning under uncertainty

- Cognitive support systems spanning clinical to lay decision making
- Data mining, machine learning, discovery from massive longitudinal and individual data

Empowered Individuals

Energized, enabled, educated

- New models of distributed and home-centered healthcare provision
- Technologies that aide in modifying self and group behavior

Sensors, Devices, and Robotics

Sensor-based actuation

- Assistive technologies embodying computational intelligence
- Medical devices, co-robots, cognitive orthotics, rehab coaches



#### Illustrative Examples of Research in Smart Health









Protecting patient privacy while providing legitimate anytime, anywhere access to health services will require new security architectures and cryptographic solutions.

Personalized medicine will require advances in information retrieval, data mining, and decision support software systems.

Continuous monitoring and real-time, customized feedback on health and behavior will rely on remote and networked sensors and actuators, mobile platforms, novel interactive displays, and advances in computing and networking infrastructure.

Virtual worlds, robotics, image, and natural language understanding can facilitate better and more efficient delivery of health services.

# Towards a Sustainable Human Future



Of all the challenges we face as a nation and as a planet, none is as pressing as the three-pronged challenge of climate change, sustainable development and the need to foster new and cleaner sources of energy.

(Office of Science and Technology Policy, Executive Office of the President)



# Science, Engineering, and Education for Sustainability (SEES)

To advance science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human well-being



Support interdisciplinary research and education that can facilitate the move towards global sustainability



Build linkages among existing projects and partners and add new participants in the sustainability research enterprise



Develop a workforce trained in the interdisciplinary scholarship needed to understand and address the complex issues of sustainability

**GOALS** 



## **Workshops Exploring Sustainability**

- DIMACS workshop on CS & Sustainability Challenge
  - DIMACS, Rutgers University, Sept 2011
  - http://dimacs.rutgers.edu/Workshops/China4/program.html
- Workshop on info. & comm. technologies for sustainability
  - SECON, Salt-lake City, June 2011
  - http://www.cs.ucdavis.edu/~liu/WICS/SustainabilityReport.pdf
- Role of Info., Sci. & Eng. In Sustainability
  - CCC workshop, Washington DC, Feb 2011
  - <a href="http://cra.org/ccc/seesit\_report.php">http://cra.org/ccc/seesit\_report.php</a>
- Science of sustainability workshop
  - Warrenton, VA, Nov 2009
  - www.nsf.gov/mps/dms/documents/SustainabilityWorkshopReport.pdf

## **Role of Computer Science in SEES**

#### **Monitoring**

- Scalable sensing & data collection for sustainability apps
  - -Ocean ice dynamics
- -Biodiversity tracking,
- -Water quality & availability
- Disaster monitoring
- -Human well being (e.g., healthcare for masses)
- Sensing in difficult environments (e.g., arctic, wild-fires, animals)
- Working with citizen science data

#### **Big Data**

- Data analytics for sustainability apps
  - -Integrating multimodal data
  - Dealing with unreliable, partial & indirect data
  - Data storage, retrieval, and provenance.
  - –Analysis, visualization, and understanding

#### Scalability

- Application specific architectures
- Massive parallelization & cloud computing
- Multi-level modeling
- Software engineering

#### **Addressing Complexity**

- Rich set of techniques
  - –Separation of concerns
  - -Symbolic modeling
  - Reasoning in uncertain environments
  - Machine learning
- –Autonomous & human assisted control

# Behavior Modeling & Change

- Theory of complex systems
- Game theory / econometrics
- Data driven behavior change
- Social networking and sustainability

#### **NSF SEES Fellows**

#### NSF 11-575

#### **Amount**

\$6 - 8M for 12 - 20 awards

#### **Awards**

2 - 3 years of fellowship costs \$88K/year in salary, \$20K/year in research expenses, \$10K/year in international research costs

#### Requirements

Applicants must be US citizens, nationals, or permanent residents

Applicants must have received PhD within 4 years of deadline

#### Restrictions

One proposal/PI

To create the necessary workforce to enable discoveries leading to environmental, energy, and societal sustainability

- The Fellow's proposed research should:
  - Cross traditional disciplinary boundaries
  - Go beyond his/her current core disciplinary expertise
  - Address issues of sustainability through a systems approach
  - Build bridges between academic inquiry, economic growth, and societal needs
- Fellows must develop a research partnership in order to broaden the impact/scope of the proposed research
- Fellows are expected to devote time to a professional development activity





#### **Innovation Corps**

To develop and nurture a national innovation ecosystem that builds upon fundamental research to guide the output of scientific discoveries closer to the development of technologies, products and processes that benefit society

- NSF-wide Initiative
- Supports NSF strategic plan: enhances our nation's economic competitiveness by "reaching out to a range of communities that play complementary roles in the innovation process and are essential to ensuring the impact of NSF Investments." 1

#### **Award Information:**

- 25 awards in FY11
- 100 awards in FY12
- Up to \$5M in FY12

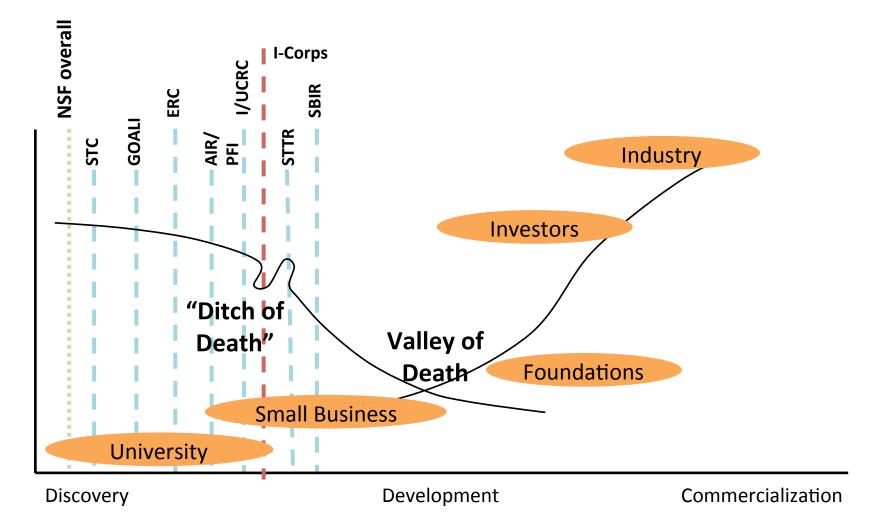
 Increases network opportunities: aims to help create a national network of scientists, engineers, innovators, business leaders and entrepreneurs, building on existing NSF grantee events.



<sup>&</sup>lt;sup>1</sup>"Empowering the Nation through Discovery and Innovation," NSF Strategic Plan, April 2011.

#### **I-Corps**

**Transcending the "Ditch of Death"**: a public-private partnership to support the translation of NSF research into the development of technologies, products, and processes.



# **Expeditions-in-Computing**

Inspire bold, transformative research that explores new scientific frontiers that promise disruptive innovations in computing and catalyze far-reaching research

10 awards made so far (\$2M/year per award for 5 years)

Year	Pre-proposals	PI, Co-PI & SP	Institutions	Full Proposals	Awards
2008	75	1000	166	20	4
2009	48	650	161	20	3
2010	23	232	76	16	3
2011	36	328	69	15	?



# **Expeditions Awards – Overview**

### **Beyond Moore's Law**

Variability-aware Software for Efficient Computing with Nanoscale Devices – UCSD, UCLA, UIUC, Stanford, Michigan, 2010

**Customizable Domain-Specific Computing – UCLA**, UCSB, Rice, Ohio State, 2009

**The Molecular Programming Project – CalTech**, U Washington, 2008

#### Wireless & Internet

Open Programmable Mobile Internet 2020 – Stanford, 2008

#### **Robotics**

RoboBees: A Convergence of Body, Brain and Colony – Harvard, Northeastern, 2009

### **Sustainability & Environment**

**Understanding Climate Change: A Data Driven Approach – Minnesota**, Northwestern, NC State, NC A&T State, 2010

Computational Sustainability: Computational Methods for a Sustainable Environment, Economy, and Society – Cornell, Oregon State, Bowdoin, 2008

### **Healthcare & Wellbeing**

Computational Behavioral Science: Modeling, Analysis, and Visualization of Social and Communicative Behavior – Georgia Tech, MIT, Boston U, UIUC, USC, Carnegie Mellon, 2010

Next-Generation Model Checking and Abstract Interpretation with a Focus on Embedded Control and Systems Biology – Carnegie Mellon, Stony Brook, NYU, UMD, Pitt, Lehman College, JPL, 2009

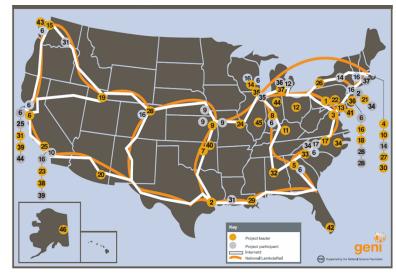
### Complexity theory, Quantum Computing & Cryptography

Understanding, Coping with, and Benefiting from Intractability – Princeton, Rutgers, NYU, Institute for Advanced Study, 2008



# Global Environment for Networking Innovations (GENI)

A virtual laboratory for exploring future internets at-scale, now taking shape in prototype form across the US



http://www.geni.net/

- Key GENI concept:
  - Slices & deep programmability
  - Federation and enabling "at scale" experiments
- GENI opens up new opportunities
  - Leading-edge research in next-generation internets
  - Rapid innovation in novel, large-scale services
- CISE mid-scale infrastructure investment



### **US** Ignite

# To create and sustain a flourishing national innovation ecosystem for gigabit application and service development



- Stitch together islands of broadband, using GENI as the glue.
- Jumpstart gigabit application development via the traditional NSF approach with grants and through competitions
- Set up a public private partnership to manage contributions, and to coordinate developer efforts, best practices, and strategic planning.

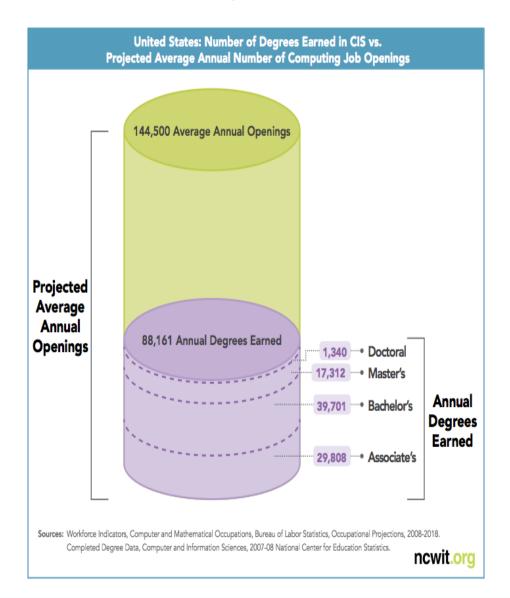


# The computing community faces three significant and interrelated challenges in workforce development

- Underproduction of degrees
- Underrepresentation
- Lack of a presence in K-12



### Underproduction



### Underrepresentation

- Women, African Americans,
   Hispanics, Native Americans and
   indigenous people, and persons
   with disabilities—together
   representing 70% of our population
   —participate in very low number in
   computing.
- While there are disciplines with lower numbers (physics and engineering), computing is the only field where the gender gap has grown over the last 20 years (mostly at the undergraduate level).



# CISE Activity Highlights





### **International Efforts**

- SAVI (Science Across Virtual Institutes)
  - A platform for International Collaborations between NSF funded US researchers and other institutions around the world.
  - Facilitate collaboration among scientists, engineers and educators across the globe to help solve society's most vexing problems.
- WIFIUS (Wireless Innovation between Finland and the United States)
  - Effort centered around wireless communication.
  - NSF funded a set of projects with US principal investigators, and the Academy of Finland and TEKES (Finnish Funding Agency for Technology and Innovation) are funding a set of collaborating projects with Finnish principal investigators.
    - 6 projects awarded to 12 PIs from 8 different institutions.
    - Alhussien Abouzeid at RPI will create a pilot Virtual Institute. This effort will work with the existing PIs of WIFIUS collaboration to build ties among all the projects.





### **Communication with Stakeholders**

### OLPA Legislative Showcases:

- Hazards on Congressional Hill
  - Search and Rescue Robots, Robin Murphy
- STEM Education Innovation at Drexel
  - Exploring Computer Science
  - CS Principles AP Course Pilot
  - SpelBots



Dr. Robin Murphy with Senate Majority Leader, Harry Reid

### Congressional Testimony/ Briefings

- Joint hearing on Cybersecurity: May 25, 2011
  - Subcommittee on Technology and Innovation & the Subcommittee on Research and Science Education
- Briefings on IT and Cybersecurity
  - Various Senate and House Committees





Thursday, October 13, 3:30pm (Rm. 110)

Prof. Lydia Kavraki, Rice University

**Motion Planning for Physical Systems** 

**Thursday, January 19, 10am (Rm. 110)**Prof. Rajesh Gupta , UC San Diego

CS&E at the Nexus of Energy and Environment: A View from UCSD Microgrid

Tuesday, November 8, 1:30pm (Rm. 375)
Prof. Daniel Spielman, Yale University

Algorithms, Graph Theory, and Laplacian Linear Equations

Wednesday, February 15, 10am (Rm. 110) Prof. William Sanders, UIUC

Making Sound Design Decisions using **Quantitative Security Metrics** 

Tuesday, March 6, 2pm (Rm. 110)

Dr. David Ferrucci, IBM

**Building Watson: An Overview of the DeepQA Project** 



# Washington Area Trustworthy Computing Hour (WATCH) Seminar Series

### Upcoming WATCH series:

 11/3/11 – Stefen Savage, "Why the hard problem of computer security needs the soft sciences" Washington
Area
Trustworthy
Computing
Hour

### Past WATCH series:

- 10/6/11 Douglas Maughan, "So what if I take over a botnet to do my research?"
- 9/1/11 Marshall Van Alstyne, "Fighting Fraud from an Economic Perspective"
- 8/4/11 Ken Klingenstein, "Trust and Turtles All the Way Down..."
- 7/7/11 Paul L. Harris, "Selective Credulity"
- 6/1/11 Fred B. Schneider, "Doctrine for Cybersecurity."



# **Recognitions in the CISE Community**



- National Medal of Science
  - Richard Tapia, Rice University
     For his pioneering and fundamental contributions in optimization theory and numerical analysis and for his dedication and sustained efforts in fostering diversity and excellence in mathematics and science education.



- MacArthur Fellow
  - Shwetak Patel, University of Washington

For his exceptional creativity and promise in inventing low-cost, easy-to-deploy sensor systems that leverage existing infrastructures to enable users to track household energy consumption and to make the buildings we live in more responsive to our needs.



# Presidential Early Career Award for Scientists and Engineers (PECASE)

- Amir S. Avestimehr, Cornell University
   For pushing the frontiers of information theory through its
   extension to complex wireless information networks and extensive
   outreach to underrepresented groups.
- **Joshua C. Bongard**, University of Vermont For innovative research in evolutionary robotics and work on robots that can learn adaptive behaviors, and for active promotion of student engagement through robotics experiments.
- **David J. Brumley**, Carnegie Mellon University For innovative and vital research on malware analysis and for strong educational and outreach activities.
- **Noah J. Cowan**, Johns Hopkins University
  For innovative research in biologically inspired robotic systems
  with application to disaster recovery and space exploration and for
  motivating students to explore careers in science and engineering.

### **Considerations**

- Industry Involvement
- Education and Workforce Development
- Midscale Infrastructure Investments



# **Agenda Review**

### Today (Tues, Nov 1):

- Update from the NSF Merit Review Process Working Group
- Breakout sessions:
  - Breakthrough Proposals
  - Encouraging Service at NSF
  - Panel quality and Quantity

### • Tomorrow (Wed, Nov 2):

- CISE Committees of Visitors Discussion
- Discussion with NSF Deputy Director, Dr. Cora Marrett
- Overview of Broadening Participation in Computing



# **Working Groups**

# Breakthrough Proposals Room 1120

- Stefan Savage, lead
- Andrew Ng
- Henrik Christensen
- Jose Fortes
- Julian Goldman
- Jon Kleinberg
- Susan Landau
- Howard Wactlar, CISE DD member

## **Encouraging Service at NSF**

#### Room 1105

- Eric Horvitz, lead
- Teresa Dahlberg
- Greg Morrisett
- James Landay
- Maja Mataric
- Bruce Hajek
- Susanne Hambrusch,
   CISE DD member

# Panel Process for CISE Room 1150

- Jim Kurose, co-lead
- Richard Ladner, co-lead
- Charles Isbell
- Anant Agarwal
- Juan Gilbert
- Jaime Carbonell
- Michelle Effros
- Keith Marzullo, CISE DD member



# Message to the Community

"CISE continues to cast a wide net and let the best ideas surface, rather than pursuing a prescriptive research agenda. It engages the research community in developing new fundamental ideas, which are then evaluated by the best researchers through the peer review process. This process, which supports the vast majority of unclassified computing research in the United States, has led to innovative and transformative scientific results with enormous economic impact and societal benefits."





# Thanks!

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